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An Experimental Approach on Robotic Cutting Arm with Object Edge Detection

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Abstract

In this paper, design, implementation and experimentation of an autonomous robot exploration system has been presented in order to fulfill the goals of object detection, cutting and removing in complex ground environment. This paper proposes a system that invades the operation of object detection and cropping of a rectangular shaped object through its edges. Our approach used fixed focus plastic lens (focal length 4.0 nm) for shape acquisition in Matlab environment. The isolated edge through graphical code was sent to Arduino IDE to perform Computer numerical control algorithm. This system is found to move the cutting hand according to the shape over the test object accurately.

Keywords: Object Detection; Cutting technique; Movement design.

1. Introduction

Advancing in autonomous robot system has been a hot topic in AI space. Several concepts were proposed in the field of robotic. For instance a robot sent to Fukushima's nuclear reactors, with an attempt to find, cut and take away liquified radioactive fuel container [1] is an example to make use of object detection and cutting. . This concept can also be helpful in the field of robotic surgery for detecting the shape of a specific region of an organ and, remove it without damaging other organisms.

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In Image processing, checking some objects' shape is often required. Depending on this, certain process can be performed on a particular object. For example, some applications demands to find out only rectangular shape among other shape. At the base level of object recognition, researchers acknowledge that, information of edge and region can be utilized to distillate an "emotive unit" in the scene. In some cases, boundary shape information, such as the rectangular shapes in aerial imagery, imply to take a crucial role [2].By image processing an image can be represented as a limited set of digital values known as pixels or picture elements. The digitization process can be operated through a scanner or video camera. Once digitalization of an image is done, different types of image processing operations can be performed. Such as edge of a digital image can be isolated using vector graphical environment and transform into graphical code [3].

Computer numerical control system consist of mechanical feed drives, motors, amplifiers, position-velocity acceleration sensors and real-time computer algorithms which creates time stamped position commands based on trajectory generation. Graphic lineaments and geometric parameters are needed to operate this system [4]. To perform machine motion for cutting, two mini stepper motors along with screw rail are needed. Both of them have to be placed horizontally so that one can use for X axis and another can use for Y axis movement. A laser diode has to be attached along with servo in such a way that the servo can control the laser. The system basically follows Bresenham's Line Algorithm for the movement of the robotic arm. For this system, the algorithm determines four points of two dimensional raster graphic in order to create an approximation straight line between the points. Our focus was to move cutting head from the point (X, Y) to (X', Y') as smoothly as possible with constant speed.

In this paper, we introduce a robotic system that can be used for detection, cutting and transportation of an object. Computer numerical control algorithm was applied for the cutting arm. The system based on computer numerical control algorithm carried two stepper motors for moving both X axis and Y axis and one servo motor for controlling the laser diode. Processing software along with Arduino worked as a brain for this system. Our robotic arm can move 73mm on x axis and 73mm on Y axis. The cutting hand was placed on a moving vehicle which has the flexibility to move on rough surfaces. For the simplicity of operation, a red squire shape object was detected on a Styrofoam board using matlab and webcam. Through different IR commands the robot was able to move in any direction. Considering availability of the equipment's and minimizing the cost, locally available components and scraps were used to build the hardware's and burning laser.

1.1. Literature Review

ArchanaTamrakar and S. N. Siddique shared a laser cutting system in [5]. One of two disadvantages of their system is there are no object detection opportunity for the cutting hand. The second one is it can't reached hazardous places without the appearance of a human. B.Moharana, Rakesh Gupta & Bashishth Kumar Kushwaha proposed a similar type of work in [6] having a cutting system on a delta robot. Same as the previous one, there is no existence of object detection system and interference with cutting arm. In [7] we had worked with a voice control movable robotic hand with self-object detection. In that, our main objective was to pick something up from any place and carry them to our desired place using only voice command. But its limitation was that, it can only grab ready-made product or things. It did not have the ability to create or more precisely

says cut anything as desired. Considering the limitations of previous work, some modifications have done in this new proposed prototype.

2. System Design

2.1. Cutting Arm processing Block Diagram

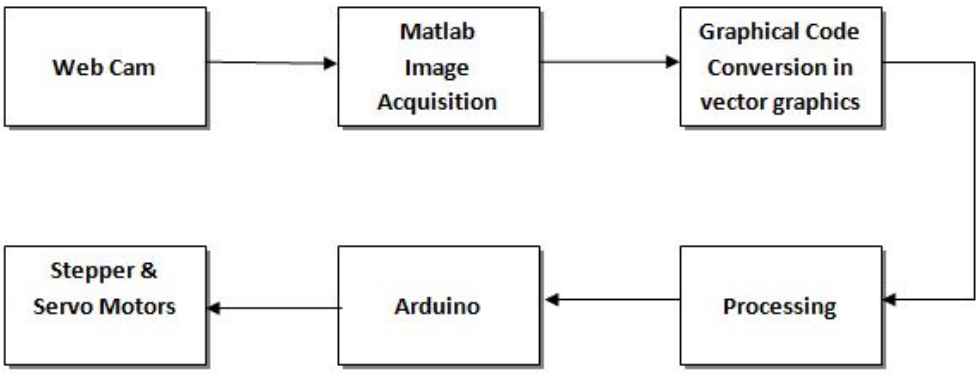


Figure 1: Cutting Arm procedure through Arduino and Processing software

Computer numerical control algorithm based robotic cutting arm uses processing software to run the graphical code and Arduino as a microcontroller, to control the steppers and servo motor. The system consists of webcam and matlab image acquisition tool to detect the shape of an object. The edge of the shape was detached using vector graphic environment and saved as graphical code. After graphical code was addressed in processing software, it starts communicating with aruduino IDE and hardware and start sending instruction to the stepper motors and servo motor.

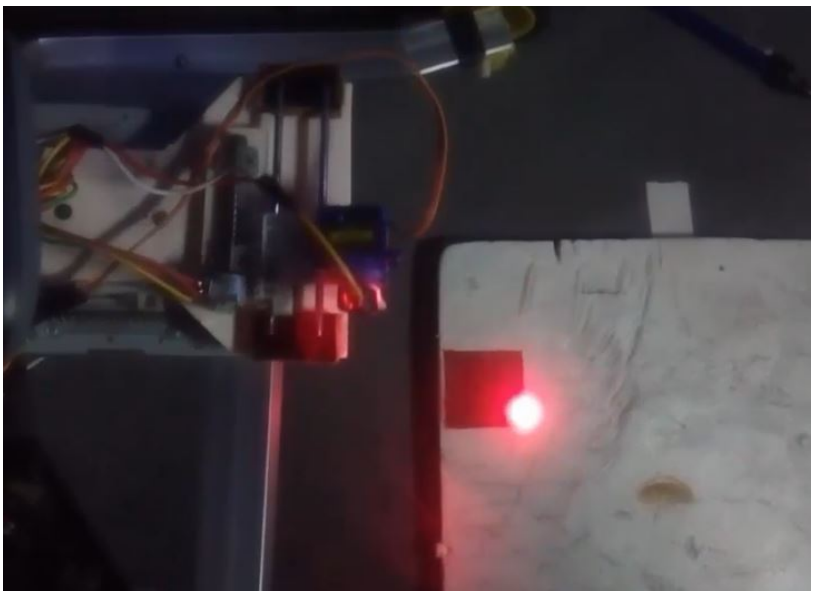


Figure 2: Cutting step using Processing and Arduino

3. Hardware and Firmware

3.1 High power Laser diode

The laser diode used for cutting, was collected from an old DVD-ROM. The diode from DVD-ROM did not have enough power to burn or cut anything. Therefore a power driver circuit was made to power up the laser diode. The laser driver circuit gives ability to the laser diode to burn .3cm deep on a Styrofoam board.

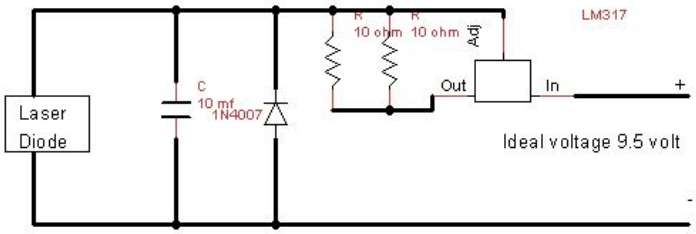


Figure 3: Circuit Diagram for High power laser Diode

3.2. Arduino IDE & Board

Arduino Uno is a microcontroller board supported the ATmega328P. Among fourteen digital input/output pins, six can be used as PWM output and another six can be used as analog inputs. A crystal oscillator, a USB port and a reset push button is associated with in this board. It has the ability to control stepper and servo motors in different angels. It contains everything required to support the microcontroller [8].

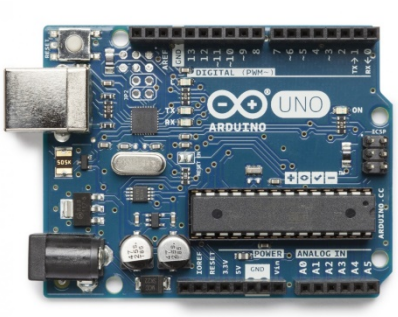


Figure 4: Arduino Uno R3 [8]

The Arduino (IDE) Integrated Development environment - or Arduino software package (IDE) - carries a text editor for writing code, a message space, text console, a toolbar with buttons for functions and a series of menus. It can communicate to the Arduino and Genuino hardware to transfer programs [9].

3.3. Processing

Processing is a versatile package sketch pad and a language for learning a way to code at intervals the context of

the visual arts. Since 2001, process has promoted package acquirement at intervals the visual arts and visual acquirement at intervals technology. The processing software is very much effective in controlling stepper and servo motors within a very specific angle [10].

3.4. IR Transmitter and Receiver

Infrared, communication in short IR is a common, cheap, and simple equipment to use as a wireless communication technology. IR light wave is incredibly the same as visible radiation, except that it's a slightly longer wavelength. This implies IR is undetectable to the human eye - excellent for wireless communication [11].

3.5. Stepper Motor

The main implementation of stepper motor is positioning of a stepper motor with appropriate precision. Stepper motor is applicable for tasks where the precision is very important factor. Application of stepper motors are computer art (hard disks, printers), automobile industry, tool machines, manipulators and actuators of industry robots etc. It is necessary control unit for stepper motor control [12].

4. Flow Chart

4.1. Flow Chart for over all Cutting Arm

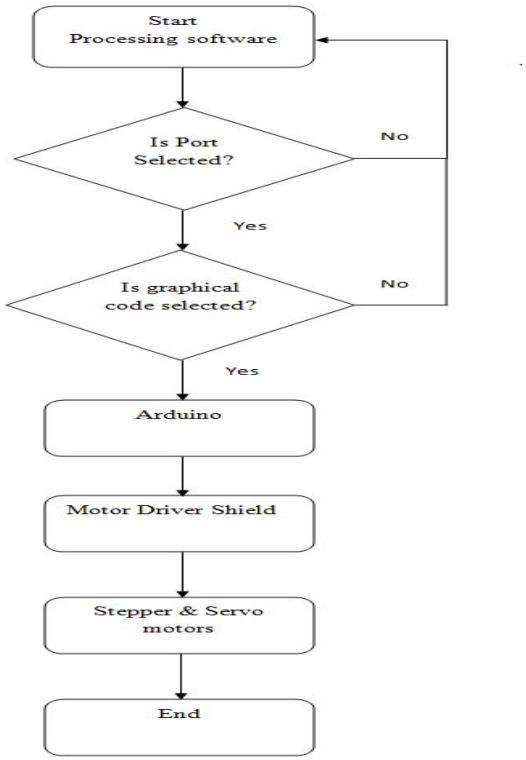


Figure 5: Flow chart for cutting arm

4.2. Flow Chart after executing Graphical code

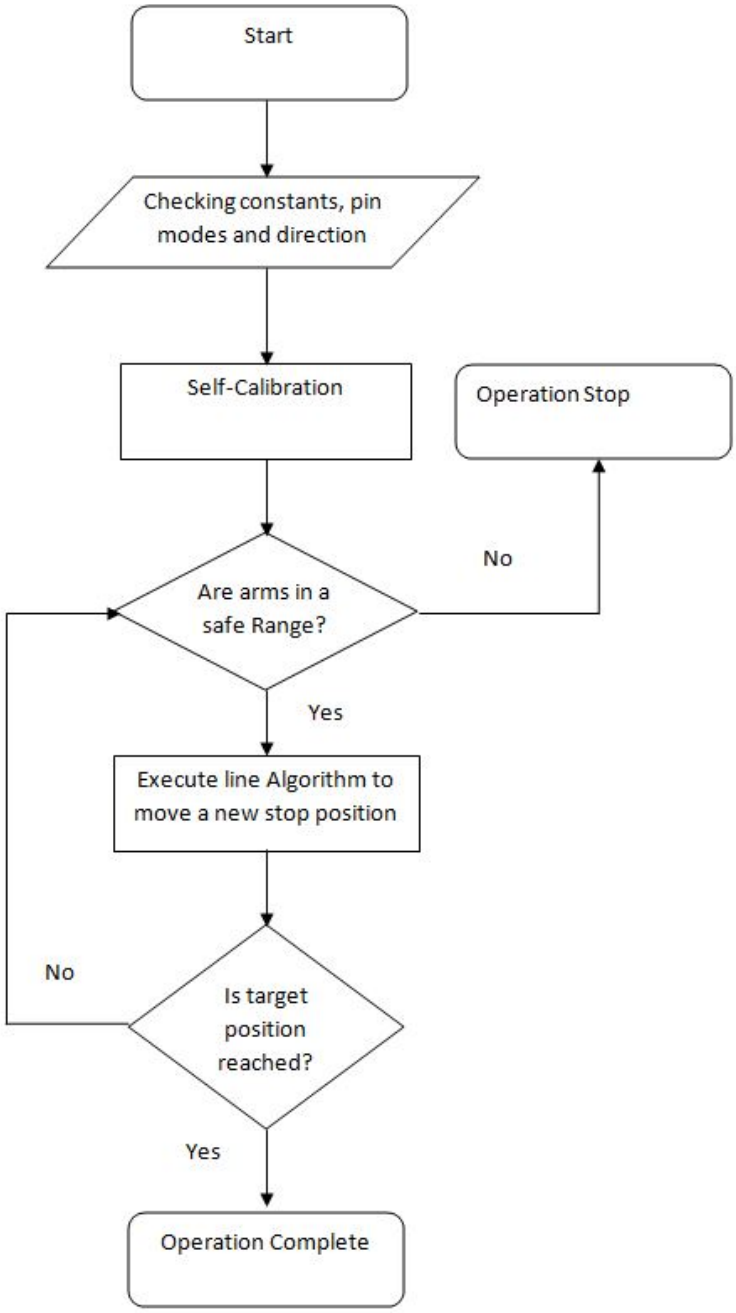
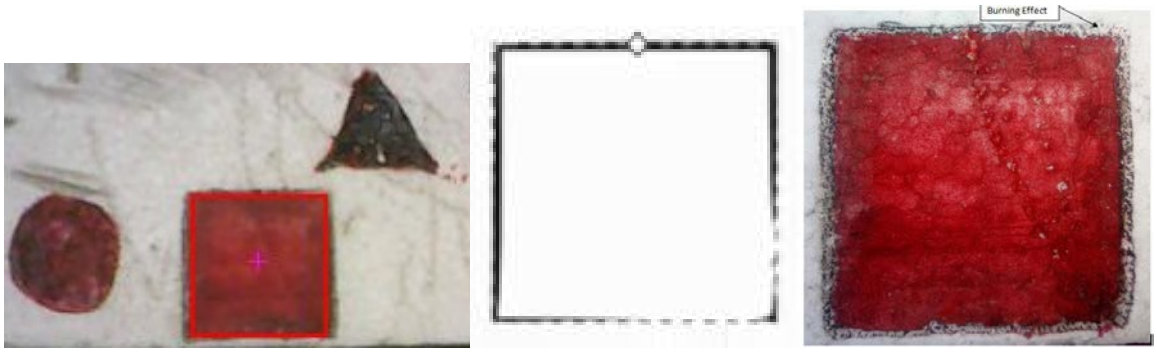


Figure 6: Graphical Code Execution flow chart

5. Experimental Result

A rectangular shape was detected on a Styrofoam board having a measurement of 4.1 cm (height) by 4.0 cm (width). Detected shape is highlighted with red line, is shown in figure7 (a).The first scenario can be expressed by isolating the edge of the detected shape as figure 7 (b) shows. In the second scenario, a two axis cutting had been performed by the cutting arm. A laser burner was attached with the arm to observe the accuracy level of the system on the test object. The system was found to be accurate while laser beam was moving exactly over

the edge of the detected rectangular shape from figure 7(a). Due to the movement of the laser beam over the edge, a burning effect (shown in figure 7(c)) was created having a measurement of 4.1 cm x 4.0 cm on the same shape. This clearly shows that measurement of the detected shape and measurement of the cutting effect is equal. A robot body was designed to carry the following system. We used four wheeler concepts along with suspension spring, so that each wheel can carry its own motor power. A full packaged robot is shown in figure 8.



(a) (b) (c)

Figure 7: (a) Rectangular shape detection via webcam. (b) Isolated Edge from detected shape. (c) Burning Effect

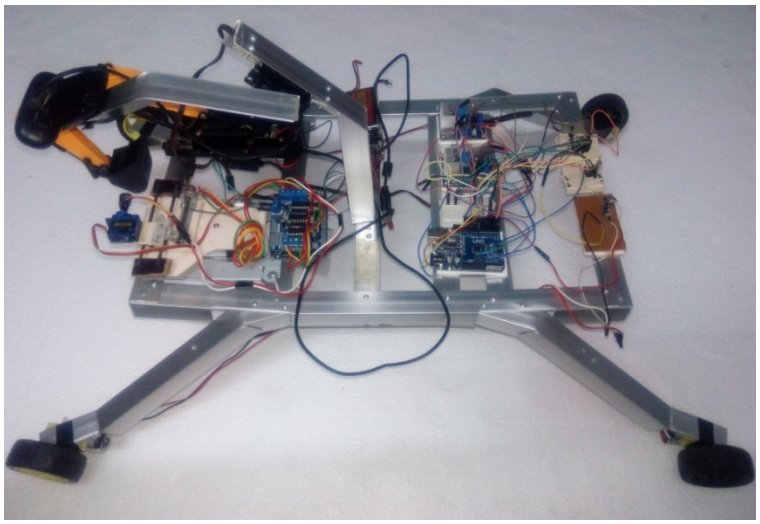


Figure 8: Packaged robot with the whole system

6. Conclusion

This experimental approach has addressed a range of analytical complication from programming to system control. Three major contributions, object detection, edge isolation and shape cutting have been introduced in details. The complete result is accomplished based on Arduino, Matlab and processing software. Robotic hand movement is based on computer numerical control algorithm along with Bresenham's Line Algorithm.

Considering the term movement capability, a robot body is designed to carry the system in remote places. This report not only tried to implement the system but also manifest the accuracy of the system. The Future work will involve developing shape detection system with stronger algorithm and increasing the measurement of stepper screw rails. To increase the controlling range, we will use radio frequency instead of IR. Larger diameter wheels can be placed and motors that have more torque can be used for increasing robot body power.

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